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(71) Applicant

Aktiebolaget Bofors (Sweden),  
S-691 80 Bofors, Sweden

(72) Inventors

Ulf Melhus  
Mats Olsson  
Nils-Gunnar Bkorkqvist  
Lars-Erik Bjorn  
Dennis Taylor

(74) Agent and/or Address for Service

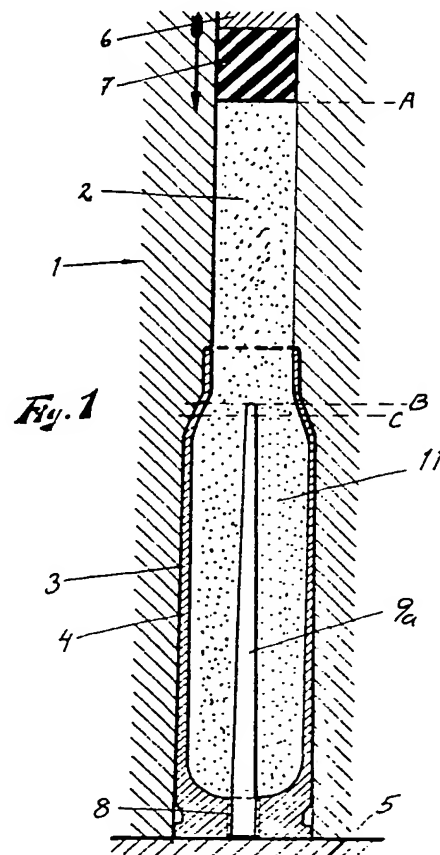
Lloyd Wise Tregear & Co,  
Norman House, 105-109 Strand, London WC2R 0AE

(54) Charging cartridges

(57) The present invention relates to a method and an apparatus for production of cartridge propellant charges for barrel weapons with charge weights up to 1.4 kg/litre.

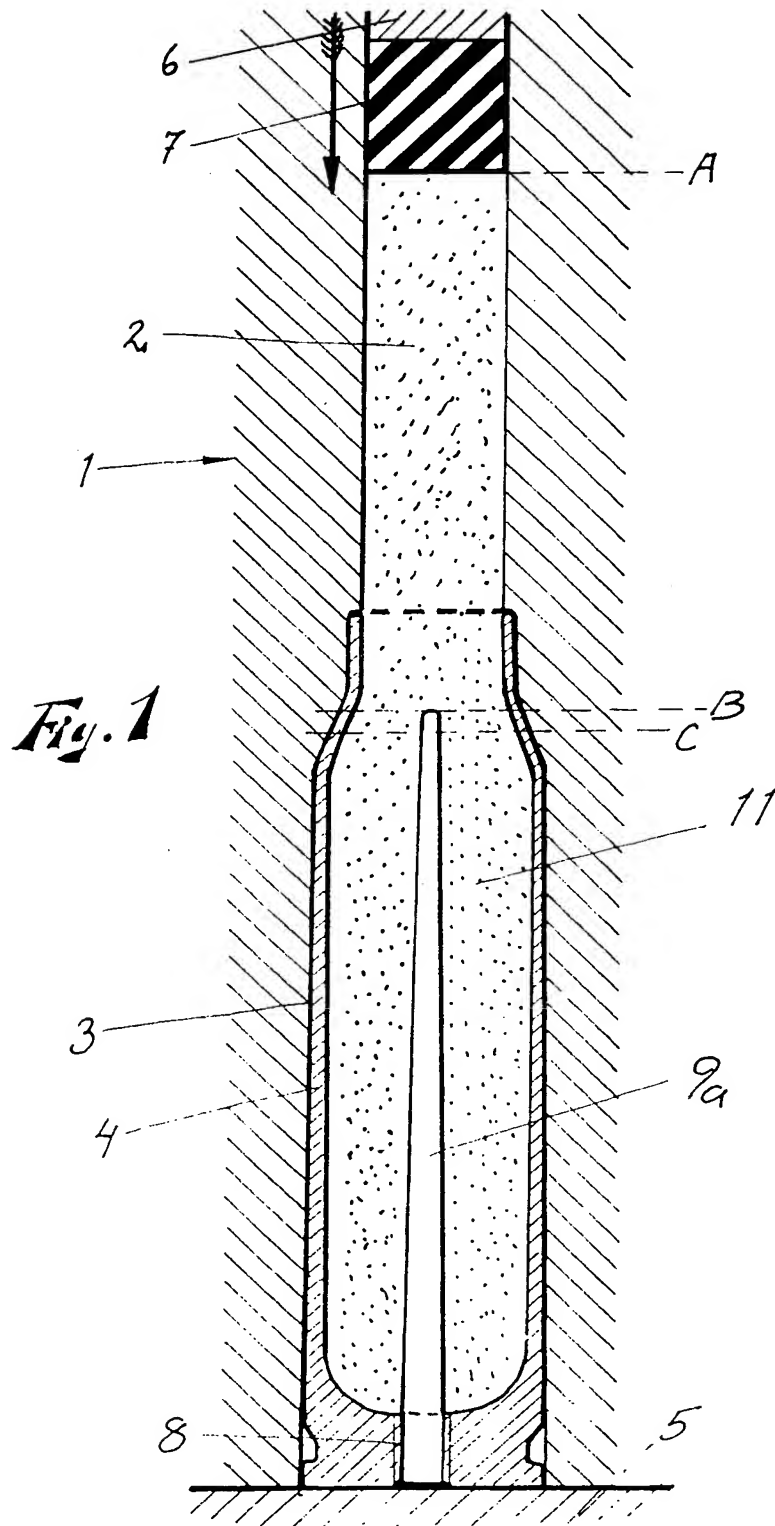
According to the invention, more granular or particle-shaped propellant powder is driven down or compacted than can be housed in free-running condition within the same volume by means of a piston or plunger (6) in a single stage down into a case (4) the inside of which is coated with a friction-reducing compound. The piston or plunger (6) can then be provided with an elastically deformable leading part (7) of e.g. rubber and/or with a conically tipped leading end (7a). According to one variant of the invention the powder is pressed down into a bag (12, 13) of combustible fibre material which has been inserted in advance down into the case (4) coated internally with a friction-reducing compound or which has itself been impregnated with a friction-reducing compound.

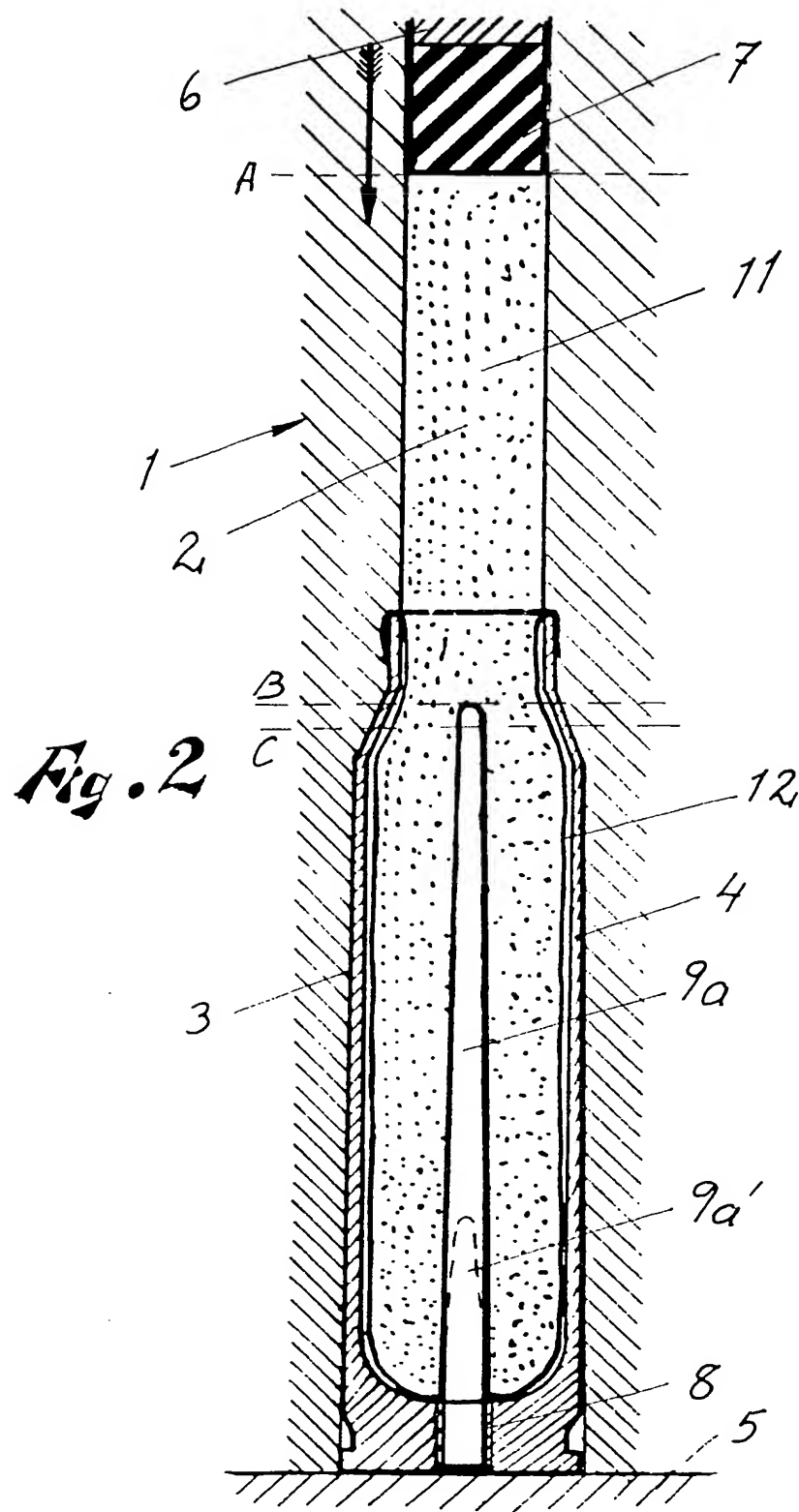
The invention also enables the powder to be compacted to advantage at a temperature that is higher than the room temperature.

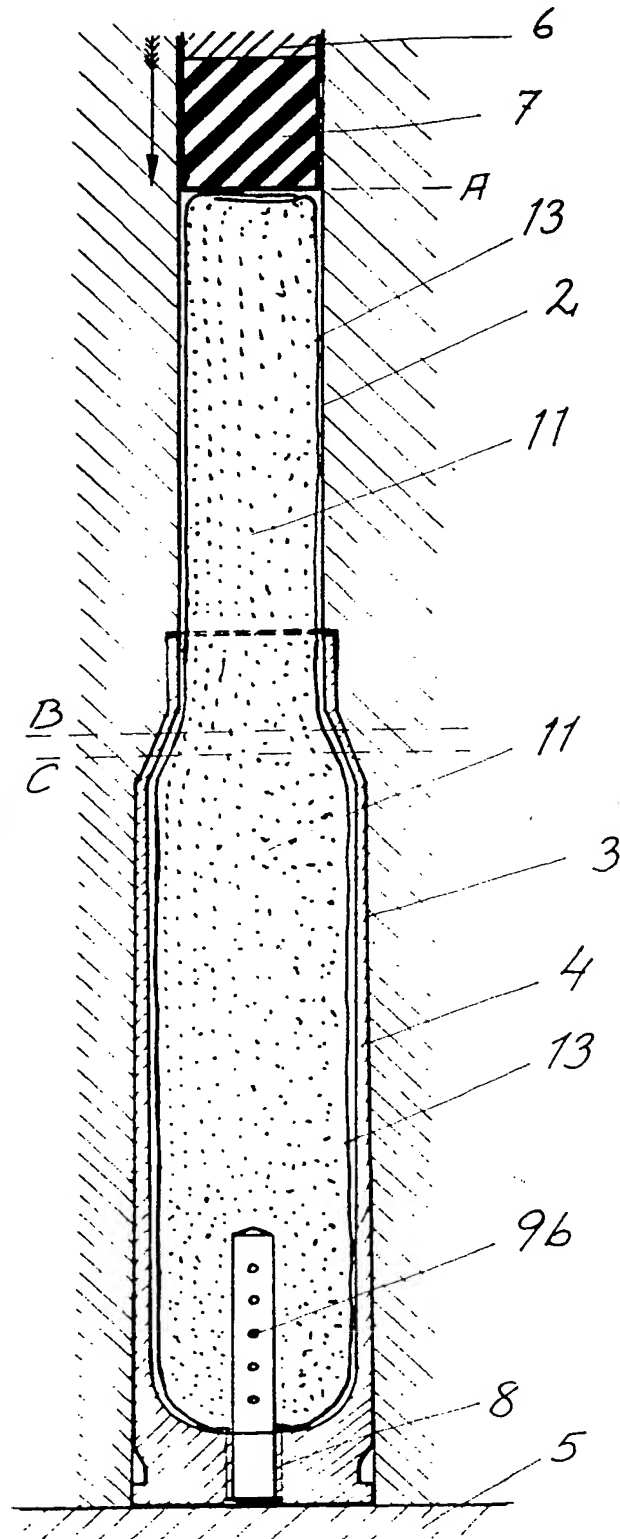


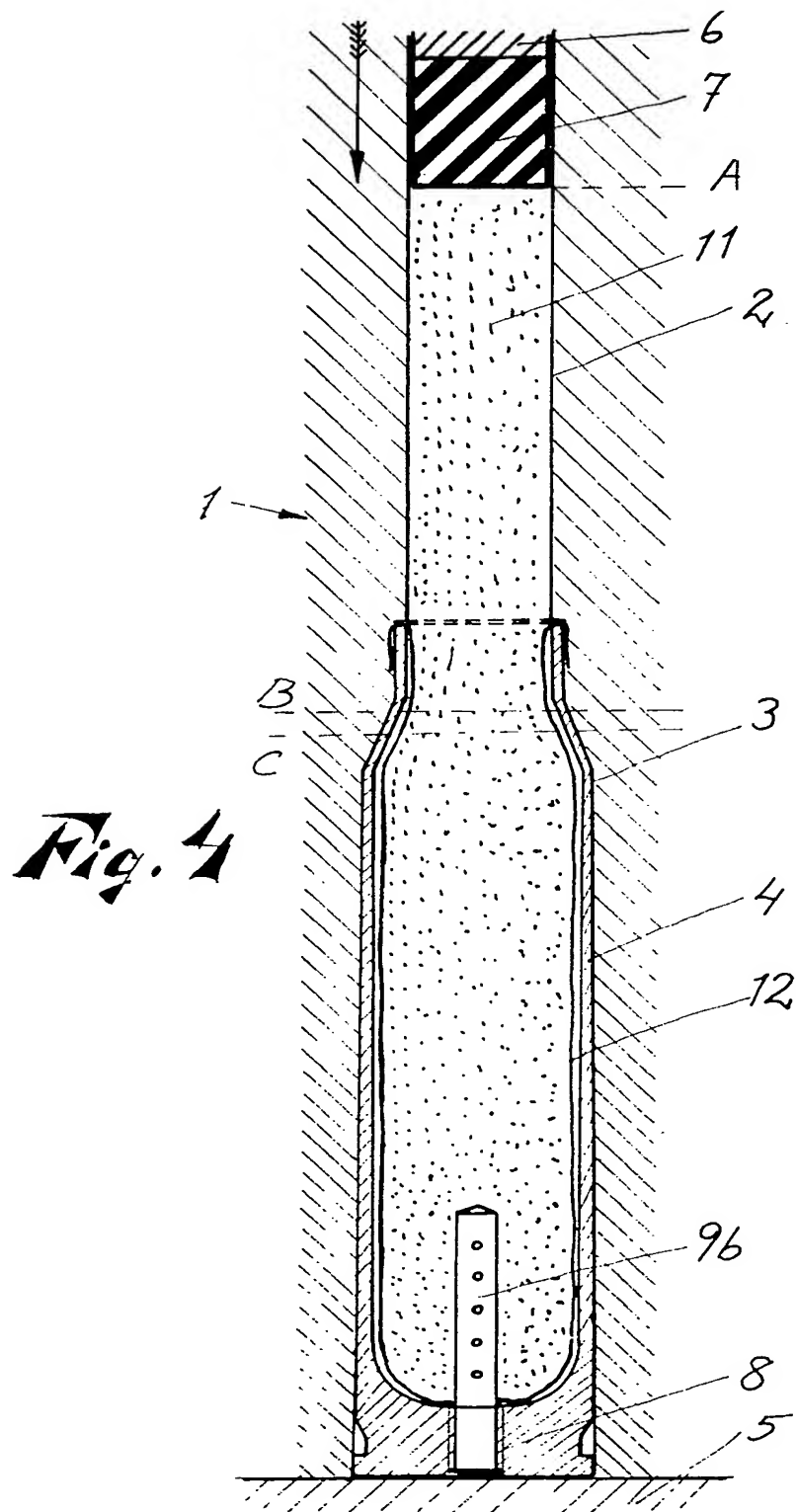
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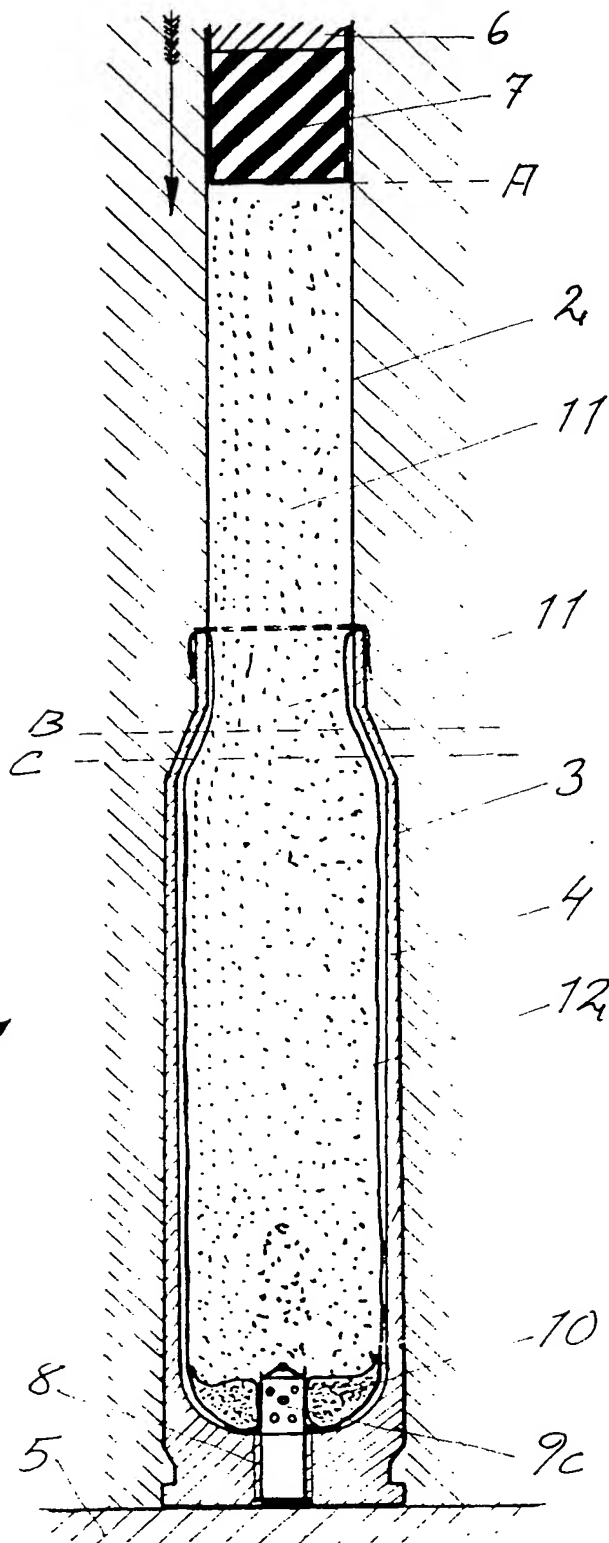
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*Fig. 3*



*Fig. 5*



## SPECIFICATION

**Method and apparatus for charging a cartridge for barrel weapons with propellant charge**

The present invention relates to a method and an apparatus for production of cartridge propellant charges intended for barrel weapons, particularly artillery guns.

The range of an artillery weapon can be increased by increasing the  $V_0$ , i.e. the velocity at which the projectile leaves the barrel. Such increase in  $V_0$  can be accomplished by an increase in the weight of the charge and/or by selecting an energy-rich propellant powder.

The propellant powder for barrel weapons is usually in the form of grains, flakes or strips which lie loose in a case or bag. Higher charge weights for a cartridge case of a given volume can be accomplished by compaction of the loose propellant powder. Any increase of the energy content in the propellant charge must, however, be combined with a simultaneous adaption of the burning properties of the propellant powder so that the gas pressure obtained in the barrel for which the cartridge is intended does not exceed the maximum permissible internal pressure  $P_{max}$  for the barrel and mechanism. With moderate compaction, the propellant powder can be compacted directly in the cartridge case without the powder grains losing their character of free grains on that account. With moderate compaction, therefore, the propellant powder is combusted in essentially the same manner as if it had consisted of loose powder.

A normal artillery powder has a specific weight of around 1.55 kg/litre. The charge density of charges with loose powder is usually of the order of 0.5 kg/litre. Theoretical calculations have shown that the best utilization of the powder may be expected at charge densities of around 1.1 kg/litre. In practice the best result can be obtained with a somewhat higher compaction.

The higher the degree of compaction, the more difficult has it proved to be to manufacture charges of uniform quality giving identical firing results. Among other things, it is a matter of compacting the powder grains without depriving them of their own shape. If the powder grains become partially pulverized, uneven firing inevitably results. The greatest risk of being crushed is run by those powder grains located close to the wall of the case or cartridge, and also the powder grains located uppermost in the charge.

Compaction of propellant powder to obtain propellant charges with high charge weights is not a completely new technique.

For example, Swedish Patent No.

71.09803-2 proposes compacting powder

grains each of which displays a plurality of

outwards pointing arms or corners it shall be possible to manufacture powder bodies which are held together through intermeshing of the arms of the powder grains.

Another method for avoiding crushing of the powder grains is suggested in DE-A-2403417, according to which the powder grains are softened-up, prior to compaction, in a solvent vapour. The problem with this method is however that it is difficult after the compaction to expel all solvent, with the consequence that residual solvent lowers the energy content of the charge, whilst at the same time the amount of residual solvent can vary both within one and the same charge and between different charges, and thereby give rise to an uneven quality, which is also dependent upon the age of the charge.

In DE-A-3205152 a multi-stage compaction is proposed in which only a small amount of the total propellant powder is filled at a time into the cartridge case, this partial amount being compacted by means of a drift which is inserted down into the neck of the case. No softening of the powder grains with solvent is performed in this context.

The present invention seeks to provide a method and apparatus enabling granular propellant powder to be satisfactorily compacted into the cartridge case, without the aid of solvents, in a single stage. Characteristic of the method according to the invention is that the cartridge case is coated internally with a friction-reducing agent. This expedient helps to prevent the powder grains closest to the cartridge wall becoming pulverized during the compaction. Better results are obtained if all the fixed surfaces along which the powder grains are displaced during their compaction are provided with a friction-decreasing coating on the surfaces; and more so still if the compaction is performed by means of a piston or plunger with an elastically deformable leading part facing towards the propellant powder, which partly brings aside for the nearest propellant powder grains and hits them from the sides instead of grinding them apart into powder during the compaction. A further advantage of the elastic plunger is that it follows the form of the compaction space as long as the change of the cross-section thereof takes place successively and is not excessively drastic. There is thus no obstacle to permitting the plunger to move down to just below the end of the neck of the case where the case commences to widen seriously.

According to what has proved to be a particularly beneficial variant of the invention the powder is pressed or compacted down into the case enclosed in a bag of a combustible fibre material. As a rule it is generally most appropriate to first place the bag in the case and then to pour in the loose propellant powder so that this fills the case and possible compaction space located outside the case.



whereupon all propellant powder is pressed down into the bag inserted in the case. It has been found that such a bag further reduces the risk of the powder grains located closest to the wall of the case becoming pulverized when all propellant powder is pressed down into the case and these powder grains must be displaced downwards in the case pressed hard against the inner wall thereof.

10 The case preferably is enclosed in a powerful matrix which in addition to a case seat also provides a compaction space above the neck of the case extending axially in the longitudinal direction of the case and with largely the same inside diameter as the neck of the case. The length of the compaction space is determined by the desired compaction of the propellant powder. Both this compaction space and the case are filled with loosely lying propellant powder before the plunger which works largely along the compression space is inserted down into this and presses the propellant powder together so that it is all forced down into the case. It is also usually appropriate to force the plunger down a little way into the neck of the case so as to form a shoulder to insert the rear part of the shell into. A final compaction is then appropriately done in contrast directly with the shell which is then forced down the last bit into the case during final compaction of the propellant powder at the same time as a grooving press or similar device fixes the shell in the case. This last compaction performed with the shell is however very small in comparison with the compaction which takes place when the propellant powder is pressed down into the case.

By coating the surfaces along which the powder is displaced in the manner indicated above with a friction-reducing agent either directly or in the form of a bag impregnated with sliding compound pulverization of the powder grains along the said surfaces is avoided in that it is compacted and pressed down into the sleeve. A mixture of pulverized and granular powder gives rise to uneven combustion which in turn can give rise to risky pendulum pressures. To further prevent the plunger itself from pulverizing the powder grains located nearest to it it has been proposed in accordance with the variant of the invention discussed heretofore that use shall be made of a plunger with an elastically deformable leading part.

It has also been found that a still better result is obtained if the powder is compacted at an elevated temperature relative to room temperature and both case and case support, plunger and any centre pin or drift which is to make room for an ignition screw may then well be somewhat warmer than the powder itself. A powder which has been heated to approx. 70 °C and which is compacted in a 90 °C warm case thus requires at most half of the compaction force which is needed for a

20 °C powder compacted in a case at room temperature. Naturally no temperatures in the vicinity of the implosion or self-ignition temperature of the powder can be considered, nor may the temperature become so high that stabilizers included in the powder are consumed. It has thus been established that powder temperatures are between 20–90 °C are suitable for compaction of granular powder whereas surrounding parts such as case, case support, plunger and possible centre pin should not have a temperature in excess of 100 °C.

Even in warm compaction the individual grains of powder retain their character of free grains but they are deformed more easily and thus adapt themselves better to one another which facilitates a raising of the degree of compaction. It has also been found that warm-compacted powder holds together better and has less tendency to crack forming.

Because powders and particularly so-called NC powders (nitrocellulose powder or single-base powder) are hygroscopic both the heating and the compaction and the cooling of the compacted powder must take place in a conditioned or closed atmosphere. This naturally involves certain complications but does not give rise to unsurmountable problems.

Because the heated powder is appreciably easier to compress the load on the grains of powder located nearest the drift appears to be so much lower that the compression, at any rate in certain cases, can be performed with a hard plunger of non-deformable material. It has also been found that the compaction of both room-temperature and heated powder is carried out more easily and with even less risk of pulverization of the powder grains if the plunger is furnished with a tapered tip facing towards the powder and preferably with a rounded top. This is regardless of whether the plunger is of elastically deformable material or not. There are no exact limit values for the angle in question but a plunger with a top angle of 30° is likely to be all too pointed and to influence to an excessive degree the powder grains in the direction towards the walls of the compression chamber instead of in a direction towards the case, whereas a top angle of approx. 160° can be expected to function roughly like a plunger with a flat front surface. Excellent results are, in contrast, obtained with a plunger with a top angle of 90°.

Before the case is filled with propellant powder certain preparations normally must be made for the ignition screw of the cartridge. Either the case can be provided with a protruding pin or drift placed in the case of the location of the ignition screw which upon removal provides room for the ignition screw and offers the requisite expansion space for this or else the ignition screw can be placed in position right from the beginning and the

propellant powder compacted around it. In the latter alternative a reinforced ignition screw is required capable of withstanding the strains when the powder is compacted around it. When the ignition screw is compacted into the powder the best over-ignition of the charge is probably obtained with a long ignition screw protruding into the case with a plurality of sideways-directed ignition openings.

The advantages of having the ignition screw compacted into the propellant powder become particularly noticeable in the case of cartridges which have been rammed at very high speed into the weapon cartridge seat, e.g. in A.A. guns with very high firing velocities, where not even small subsidances in the charge, e.g. in a small play around the ignition screw, can in any circumstances be accepted.

In order to obtain uniform over-ignition of even relatively firmly compacted powder special ignition arrangements are thus required, for instance in the form of a long so-called ignition screw which extends centrally along at least the main part of the length of the charge and which ignites along its entire length.

Another method which has proved to give a surprisingly uniform over-ignition is to compact the powder around a centre pin protruding into the case and screwed into the seat of the ignition screw, which pin is removed after compaction has been completed whereupon the space left behind by the centre pin when it is screwed out of the ignition screw seat and withdrawn rearwards from the case is filled with loosely powder which in turn is ignited with a conventional short ignition screw.

According to our experience the best way of minimizing the friction between the grains of propellant powder and the wall of the case and the inside of the compaction space respectively, alternatively between the outside of the bag and the wall of the case and the inside of the compaction space respectively is to coat the fixed surface with a sliding lacquer. Tests with bags impregnated with sliding compound have not given the same good results throughout. The best results have been obtained by applying a teflon "(RTM)" coating to the inside of the case and the compaction space. The teflon has then been applied with the aid of solvent but without heat.

With regard to the bag this can either be given such a form that it extends along the entire case and up along the compaction space and thus is forced upon compaction of the powder down entirely into the case together with the propellant powder, or else it can be shaped so that it only fills the case and is folded down around the opening of the neck of the case. In the latter case it must be anticipated that the bag will burst along the fold, if not before then when the plunger goes down into the neck of the case. Both elabora-

tions of the bag appear to give roughly equivalent firing results. The bag can be provided right from the beginning with a screwed-in ignition charge in the bottom. The method according to the invention also permits the charge to be produced from several different types of propellant powder which are supplied in layers or in a mixture and subsequently compacted together.

The bag itself may be of an entirely conventional quality and consist of a combustible, appropriately woven textile material such as cambric.

In the preferred embodiments of this invention, it is possible to compact all the propellant powder into a cartridge case in one single stage and yet achieve high charge weights, up to 1.4 kg/litre, of substantially uniform quality.

Embodiments of the method and the apparatus according to the invention will now be described in greater detail and with reference to the accompanying figures.

Figs. 1-6 show a longitudinal section through different devices for performance of the invention. Fig. 7 shows a longitudinal section through a ready-charged cartridge. In the variants shown in Fig. 1 and Fig. 6, no bag is used whereas in the variants according to Fig. 2-5 different types of bag are used.

Identical parts in the various figures have been given the same reference numerals. Shown in all figures is a matrix or compacting support 1 comprising a leading cylindrical compacting space 2 and a rear cartridge seat 3 disposed axially with the compaction space in which a case 4 has been applied. The case 4 is retained in place in the case seat by means of a stop or backpiece 5. Disposed in the compaction space 2 is a displaceable piston or plunger 6-6a with which loose propellant powder 11 which has previously been poured into both the compaction space and the case is pressed completely down into the case in one single stage. Since the end position of the plunger is given the amount of loose propellant powder 11 filled into the compaction space 2 will determine the final degree of compaction of the charge.

The plunger 6 is made of metal but has an elastically deformable leading part 7, appropriately made of rubber with a hardness of 15-100 shore.

The case 4 is provided with a bottom thread 8 into which an ignition screw can be screwed. Two different types of ignition screw 9b and 9c are shown in Fig. 3-5 and are described in greater detail further on in the text. In Fig. 1 and Fig. 2, the ignition screw is replaced during the compaction of the propellant powder with a pin or drift 9a introduced through the bottom thread 8 of the ignition screw. Upon completion of the compaction the pin 9a is removed. Since the propellant powder has then become sufficiently held

together the pin 9a will leave behind it a cavity in which the ordinary ignition screw can be mounted. Shown in Fig. 1 and Fig. 2 is a variant with a long pin 9a which gives a long through-going ignition passage throughout the entire case. Either a short or a long ignition screw can be mounted optionally in this ignition passage. The whole of or parts of this ignition passage can also be filled with loosely lying ignition powder.

In Fig. 3 and Fig. 4 the case 4 is mounted with a long ignition screw 9b of reinforced side-igniting type. This is compacted firm directly in the propellant powder and must therefore be so sturdy as to be capable of withstanding the stresses then arising.

In Fig. 5 the ignition screw is of a similarly reinforced but short side-igniting type. This too is compacted firm directly in the powder. In the figure it is however combined with a special ignition charge 10.

In all the alternatives shown in Fig. 1-6, the plunger 6 is displaceable from its initial position A shown in the respective figure to the second position B shaded in the figure where the leading end of the plunger has reached slightly down into the neck of the case. The position C marks the rear edge of the projectile when fitted in place. Since the plunger 6 only goes down to position B a last final compaction must take place with the projectile which is pressed down into the case at the same time as the projectile is anchored in the case e.g. by swaging of the neck of the case to the projectile with a grooving press.

As evident from the marking B in Fig. 1 and Fig. 2, the elastic leading part of the plunger 6 may very well meet the pin 9a. This can be permitted since the leading part 7 of the plunger is elastic and the intention of this is that the pin when it is removed shall leave behind it an ignition passage which extends along the entire case. Obviously use may also be made of a relatively short pin which only makes room for an ignition screw and in this case it will not be a matter of the pin and the plunger meeting since the length and shape of the pin is then completely adapted to the ignition screw.

A variant of a short pin is marked with a broken line in Fig. 2 under reference numeral 9a'.

In the arrangements shown in Fig. 1-5, the inside of the compaction space and the inside of the case 4 have been coated in advance with a friction-reducing agent, for example a teflon-based sliding lacquer. In the variants shown in Fig. 2-5, use is also made of bags which have been inserted down into the cases 4 before the loose powder 5 has been filled into both the bags and the respective compaction spaces 2. The bags are of two types. A shorter bag type 12 is used according to Figs. 2, 4 and 5. It is inserted into the case and folded around the neck of the case and held

in place by the matrix 1. A longer bag type 13 is used according to Fig. 3. The bag 13 then extends along the entire compaction surface of the matrix and down into the case 4.

In the case of the shorter bag type 12, the powder is pressed from the compaction space down into the bag. It must then be anticipated that the bag 12 will burst along the folder round the neck of the case, if not before then when the plunger reaches the neck of the case. In the variant of the bag 12 shown in Fig. 5 an ignition charge is sewn into the bottom of the bag. The ignition screws 9b and 9c and the pins 9a and 9a' are inserted into the bags through a special bottom hole in these. This is in order for the bags not to prevent a rapid and correct over-ignition of the propellant powder. When the longer bag type 13 according to Fig. 3 is used, the upper end of the bag is folded down after the bag has been filled with loose propellant powder whereupon both the bag and its contents of propellant powder are pressed by the plunger 6, 7 completely down into the case 4. In consequence of the negligible friction of the bag against the walls of the compression space and of the case, which are coated with sliding lacquer, pulverization of the powder grains along the walls is avoided. In that the leading part 7 of the plunger 6 is made of an elastic material pulverization of the uppermost powder grains located nearest the plunger is also avoided. In the final analysis it is the type of propellant powder that decides if the variant according to Fig. 1, i.e. without a bag, can be used or not.

The air present between the propellant powder grains in the loosely lying powder can be diverted in several different ways in conjunction with the compaction. If a pin of type 9a, 9a' is mounted instead of the ignition screw the air may for example be permitted to pass the side or through holes in the pin. It is also feasible to permit the air to escape past the plunger or to evacuate the air immediately before the plunger is displaced from its starting position A.

As evident from the figures, the final position for the leading part 7 of the plunger 6 is situated just below the end of the neck of the case where the case seriously commences to widen. This can be permitted since the leading elastic part of the plunger expands in pace with the space available at the time, provided that the change in area attained at any instant does not take place too rapidly or is too large.

Fig. 6 shows a device suitable for compaction of powder heated to a temperature higher than room temperature. A slidable drift or plunger 6a with a conical tip 7a is disposed in the compaction space. The tip 7a has a top angle of 90°. The conical tip can consist of a fixed or elastically deformable, not excessively soft material. The case 4 is provided with a bottom thread 8 for screwing in an ignition

screw 9d (Fig. 2). Fig. 1 shows a centre pin 9a screwed into the bottom thread 8. The case 4 and the compaction space 2 are completely filled with loose powder. Both the compaction space and the inside of the case and by all means also the outside of the centre pin 9 have been coated with a friction-decreasing compound. The powder is heated to max. 90 °C, whereas other parts have a temperature of max. 100 °C. By driving down the plunger 6-7 from its starting position A to its stop position B all the powder is forced down into the case 4. The conical front of the plunger lowers the pressing pressure and guarantees satisfactory packing of the grains of powder, primarily in that part of the charge which is located closest to the neck of the plunger.

Fig. 7 shows the finished cartridge with the compacted powder 11b. A projectile P has been mounted in the neck of the case. This reaches roughly equally far down into the neck of the case as the plunger 6-7 in its lowermost position. The plunger, in contrast, occupies a slightly greater volume and consequently a final compaction of the powder can take place with the projectile when this is pressed into position. The centre pin 9a has been removed and the space which it leaves behind it in the compacted powder has been filled with loose ignition powder T and a short ignition screw 9e has been mounted in the bottom thread 8.

### CLAIMS

1. A method of charging a cartridge for a barrel weapon with a propellant charge, by compaction of the propellant powder into the case of the cartridge with the aid of a piston or plunger, wherein there is used a cartridge case which is coated internally with a friction-reducing agent.

2. A method according to Claim 1, characterized in that both the cartridge case coated on its inside with a friction-decreasing coating and a space outside the case, similarly internally coated with a friction-decreasing compound which communicates with the interior of the case is filled initially with free-running granular or particle-shaped propellant powder whereupon all this propellant powder is pressed into the case by means of this plunger which is movable along the said space.

3. A method according to Claim 2, characterized in that compaction of the powder is performed by means of a plunger displaceable in the neck of the cartridge case and provided with a pointed leading end facing towards the powder.

4. A method according to Claim 1 or Claim 3, characterized in that compaction of the powder takes place with a plunger the front part of which facing towards the powder consists of an elastically deformable material.

5. A method according to Claim 1 or

Claim 4, characterized in that the power grains are compacted in the cartridge case at a temperature which exceeds room temperature but does not exceed 90 °C.

6. A method according to Claim 5, characterized in that the powder grains are pressed down into the cartridge case by means of a plunger which together with the said case and other details with which the powder comes into direct contact is maintained at a temperature which exceeds the powder temperature but which does not exceed 100 °C.

7. A method according to Claim 1, Claim 3 or Claim 5, characterized in that a bag of a combustible fibre material is inserted in the cartridge case coated internally with a friction-decreasing compound and that the granular or particle-shaped propellant powder is filled and compacted inside this bag.

8. A method according to Claim 7, characterized in that a bag of a combustible fibre material is applied in both the case coated internally with a friction-reducing compound and the compression space located outside the case whereafter both the part of the bag outside and the part of the bag inside the case is filled with free-running granular or particle-formed propellant powder, whereafter the part of the bag located outside the case with its contents of propellant powder is pressed by the plunger completely down into the case during mutual compaction of all propellant powder.

9. A method according to Claim 5 or Claim 6 characterized in that heating of the powder to compaction temperature, compaction of the powder and all handling of this until it has again cooled to room temperature is carried out in a conditioned atmosphere with a humidity selected in advance in view of the powder and the actual temperature or enclosed vessels which are handled in such a manner that the humidity of the powder is not changed.

10. A method according to any of the preceding Claims, characterized in that a side-igniting ignition screw protruding in the case in assembled condition is disposed in the case before the granular or particle-shaped propellant powder is supplied and that the propellant powder is compacted around the ignition screw.

11. A method according to Claim 1, characterized in that a drift is mounted in the place of the ignition screw so that the drift protrudes from below into the case whereafter the propellant powder is filled in free-flowing form and compacted around the drift which is then removed in order to make room for the ignition screw and at least a certain amount of loosely filled non-compacted ignition powder.

12. Apparatus for production of cartridge charges with high charge densities characterized in that it includes a matrix with a cartridge seat (3) adapted to the cartridge case

(4) concerned which also displays a compression space (2) disposed in the elongation of the case seat above the open neck of the case into which a plunger (6) is axially displaceable  
5 from an initial position (A) which in the case (4) and said space (2) makes room for the entire amount of propellant powder (11) in non-compacted free-running condition, to a  
10 second position (B) where all propellant powder has been forced down into the case (4).

13. Apparatus according to Claim 12 characterized in that the case seat (3) of the matrix permits a bag (13) inserted into the case (4) to have its outermost part folded  
15 around the open neck of the case and secured between this and the case seat when the case is in position in the case seat.

14. Apparatus according to Claim 12 characterized in that the plunger (6a) has a  
20 conical tip facing towards the compaction space.

15. Apparatus according to Claim 12 or Claim 13, characterized in that the front part of the plunger (6a) is made of an elastically  
25 deformable material.

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